Proposed
Fuel Element Debris (FED) Dissolution
at
Hinkley Point (Somerset)
:
Implications for South Wales coastal regions and populations

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Source of FED

- First generation of UK reactors (Magnox) fuelled by uranium fuel elements clad with magnesium oxide alloy.
- Starting in mid 60's, used fuel elements (HLW) removed from Magnox reactors & stored in "cooling ponds" to reduce radioactivity levels

- From 1969, mechanical "stripping" of magnesium alloy components conducted (underwater) while fuel elements in cooling ponds
- Wet FED wastes put in skips and later removed to storage vaults *(stored wet or dry: vaults above and below ground)*
- *"stripped" used fuel sent to Sellafield for re-processing using nitric acid dissolution*

- Ongoing production of FED wastes due extended life spans of youngest Magnox stations…(Hunterston: Scotland & Wylfa: Ynys Mon)

- De-fueling of Bristol Channel Magnox's now complete

The HINKLEY FED proposal

- **NDA National Policy/Strategy: REDUCE MAGNOX SOLID WASTE HOLDINGS BY A FACTOR OF +20**

- **Construct 2 FUEL ELEMENT DEBRIS dissolution plants at HINKLEY POINT , Somerset coast & Bradwell, Essex coast**

- **Operational Phase 1:**
- FED dissolution plant to re-process FED from decommissioned Hinkley A station (2 Magnox reactors)
- Encapsulate solid radioactive wastes for ongoing storage at Hinkley prior to future disposal *(National Geological Disposal Facility)*
- Discharge liquid radioactive wastes to Bristol Channel

- **Operational Phase 2**
- **Transport FED from decommissioned Oldbury A station** (2 Magnox reactors) to Hinkley site
- Encapsulate solid radioactive wastes for ongoing storage at Hinkley *(NGDF)*
- Discharge liquid radioactive wastes to Bristol Channel

- **Duration** of FED dissolution at Hinkley uncertain…. 5 to 10 years?????

Hinkley/Oldbury Fuel Element Debris consists of:

- 1: Magnox components (fuel element cladding, cooling fins, lugs, splitters & swarf) stripped from used uranium fuel elements from 1st generation : "Magnox A" reactors
- *This material is highly radioactive (fission & activation products) and may contain fragments of "tramp" fuel on interior and exterior surfaces due to manufacturing weaknesses in the magnox cladding*

- 2: Additional FED metal wastes consist of "fuel element end fittings", nimonic springs, thermo couple wires
- *These wastes have their own unique radiological finger prints…typically very high levels of Cobalt (Co) 60 and radioactive nickel*

- 3: Unquantified amounts of used fuel fragments removed from fuel elements during "stripping"
- *This material consists of highly radioactive alpha/actinides (Uranium, plutonium, americium, curium) and other forms of radioactivity*

- 4: un-quantified volumes of radioactive "sludges" and gravel from the bottom of FED storage "vaults", "skips" etc

Outline of proposed Hinkley Dissolution process

- **Current "project assumption"** that end fittings,fuel particles etc will be segregated prior to treatment *(some small scale trials underway)*
- FED dissolved in nitric acid using a process similar to that used at the Sellafield reprocessing plant

- Process produces **"**reduced volumes" **of solid residues** consisting of magnesium nitrate, multiple radio nuclides and heavy metals *(solid residues packaged in containers for on-site interim storage prior to future disposal in* ***"Geological Disposal Facility")***

- Process produces high volumes of **liquid wastes** containing multiple radio nuclides and heavy metals
- Liquid wastes to be treated at "abatement plant" prior to discharge
- "Abatement" to consist of filtration followed by dilution with "ambient" water
- filtration will remove some solids but no detail (as yet unanswered FoI request)
- Proposed liquid discharges to sea on high tide (ebb cycle)

- Concentrations of radio activity and heavy metals "within permitted limits

FED dissolution: marine discharges
NFLA FOI requests: MAGNOX Ltd response

- **Table 1:** 20 radio nuclides including H3, Co 60, Pu (2), Am (1), Sr 90 *(but not Cs 137)* in liquid rad' waste stream

- **Table 2: "Estimated quantities of each constituent radio nuclide in liquid waste stream"**
- **only actually provides estimated quantities for 2 nuclides ……**

  1: Tritium (H3) cannot be "abated"

  Tritium annual limit 7 TBq :"predicted" 6.55 TBq per annum (6,550,000,000,000 Bq)

  18 months expected = 9.82 TBq

  2: Cs 137 *(not listed in Table 1)*

  No individual quantifying data for the 19 "other" nuclides listed

  including alpha emitting Pu 240, Pu241, Am 241 et al….

Hinkley Tritium (H3) discharges in context

2012 limits	**2012 "actual"**	***FED H3*** *Annual consent*	***FED H3*** *predicted actual*
Hinkley A= 1 TBq Hinkley B 650 TBq	Hinkley A 0.118 TBq Hinkley B 153 TBq *(Bristol Channel largest input)*	*(Bradwell)* *7TBq*	*(Bradwell) 6.55TBq*
New Build Station consent 150 TBq	New Build Station future actual?????? 104 TBq	*Bristol Channel currently has 6 sites discharging liquid H3 to Bristol Channel*	*FED will be second largest source of H3 until Hinkley C operational (then third)*

Environmental Behaviour & Fate of Tritium

- Tritium is an isotope of Hydrogen (H) : natural forms: but also fission product of reactors, bombs etc

- No current reactor technologies which DO NOT generate tritium

- No abatement technologies, can't be captured or sequestered at nuclear sites
- **Sites can't operate without tritium production**
- Discharging to atmosphere in gaseous/vapourised form as HT
- Discharging to sea as "tritiated water"
- H3 Limits appear designed to permit necessary discharge

Liquid Tritium discharges and human exposure:1

- Environmental behaviour like any other form of water: *readily detected wherever analysed for in Bristol Channel*
- Environmental half life = approx 12 years: beta emitter: relatively high specific activity
- **Due to 50 years + regional radioactive liquid waste discharges**

  BC Water columns have higher concentrations than most other sea areas

  BC Sediments have higher concentrations than other sea areas*(18 to 2,5000 Bq/Kg)*

  Available wildlife samples (shellfish, fin fish, duck, waders etc) very high levels of bio-accumulation
  (cod:33,000 Bq Kg,
  mussels: 26,000Bq kg, wildfowl 61,000 Bq Kg)

Liquid tritium discharges and human exposure:2

- Organic bonding (due to bio-exchange of tritium with other hydrogen forms in organic molecules (fats/lipids etc) = food chain accumulation
- Fully dissolves in saline, brackish and fresh water,
- Behaves like any other “water”
- High potential for sea to land transfer (sea spray/marine aerosols, vapours)
- Human exposure pathways = skin, inhalation, ingestion (at sea and deep into terrestrial zone) *(RADMID Cs 137)*

- 99% of tritium absorbed in human body : retained & distributed evenly to all organs
- Human body half life = 10 days
- **Health risk = ionising radiation damage to cells**

Alpha emitting “actinides”

- 15 radioactive metals in FED liquid discharge*(five naturally occuring)*
- 10 man made (including **Plutonium, Americium, Curium, Neptunium**) produced by irradiation of Uranium fuels
- Present in liquid discharges in dissolved or particulate state
- Pu, Am, Cm etc characterised by very long half lives *(Pu 239: 24,000 years)*

- Liquid discharged actinides show strong tendency to “transfer” across media
- by AD-sorbtion to sedimentary particles in water column
- Deposition into fine sediment environments where become “re-concentrated” over water column ambient
- Re-concentration in marine microlayers (EFs x 5)
- Re-concentration in sea surface micro algal blooms (EFs x 26,000 for Pu)

- Re-concentration in coastal sea spray and aerosols (EFs x 347 for Pu239 & x 812 for Am 241)
- Actinides suspended in sea spray and aerosols cross the intertidal zone: inland penetration

Coastal populations: exposure pathways for alpha emitting actinides

- **Coastal studies of 3 Pu, 1 Am** + Cs 137
- **Inundation** (salt marsh/coastal pasture, urban: TOWYN)
- **Sea to Land Transfer** (sea spray/aerosol: RADMID, Uist)
- **Sea foods and coastal/maritime occupation** (RIFE)

Dose pathways via

- ***Ingestion:*** 1:terrestrial foods 2: secondary=sea foods,
- ***Inhalation:*** 1: marine aerosols/seaspray, 2: airborne v.fine sediments from (summer exposed) mudflats, 3: vapour/mist [from drying mudflats], 4: house dust,
- ***Contact/skin doses*** *(cuts/abrasions)*

- *Remember : Linear No Dose Threshold!*

Dungeness (optimum site!) : **7** Transuranics in **mud & sand**

(Monitoring for Pu x3, Am x1, Cm x3). *Rye Harbour : (7.5 miles distant)*

Yearly Average: 12 years **1988-** 1999	Plutonium 239/240 0.47 Bqs/Kg
Yearly Average: 7 years ***2000 2006***	***Plutonium 239/240*** ***0.94 Bqs/Kg*** ***(doubling)***
2007 - 2012	**Change of site to one where sediment samples return “less thans”!**

Bristol Channel Marine Parameters

- **Bristol Channel NOT optimum site due:**
- Multiple liquid radioactive discharge sources *:*
- *Cardiff 2 [+ Llanishen]*, *Odlbury 1*, *Berkeley 1*, *Hinkley 2 [future FED & Hinkley C]*
- Semi enclosed sea area: relatively slow flushing time:
- Extended life span of rad' wastes in system

- Very High sediment loading
- High volume freshwater inputs
- Extensive inter-tidal and sub-tidal sediment deposits
- Water column movement = transport along South Wales coasts

Poor knowledge of BC marine hydrodynamics

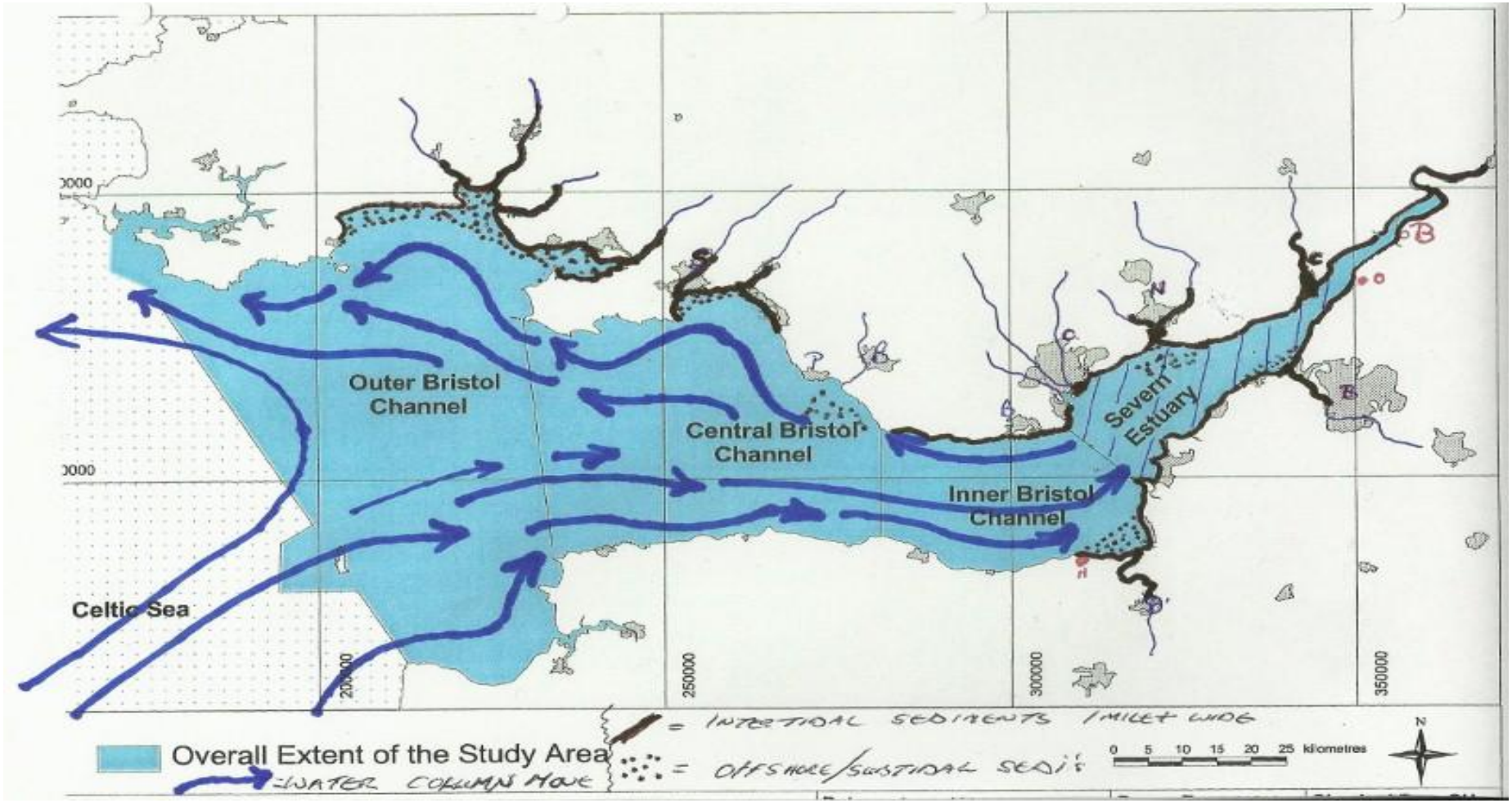
- **Recent research identifies major gaps in knowledge of BC hydrodynamic processes as they relate to pollution behaviour:**
- **2010 Mar Poll Bul':** much of the research is several decades old and needs updating
- Many factors controlling and effecting the behaviour of suspended sediments *(distribution and deposition)* remain unknown or unclear:
- Salinity/freshwater interactions
- extent and nature of biological processes
- Conclusions include:"interpretation of the significance of this process is only just beginning to emerge"
- "better understanding of these features and their linkages would improve management options for the (BC) system"
- *Mar Poll Bul 2010 published before Hinkley C permit applications granted : no evidence that GDA or the permitting process for FED discharges benefited from "new" data or took note of the conclusions of the Mar Pol study*

Bristol Channel fine sediments

- **Fine sediment deposits = major sinks of radioactivity** *(particulate adsorbtion and "interstitial water")*
- 2010 tracer studies demonstrate that the most extensive depositions of fine sediments are found at:
- **Bridgewater Bay** *(immediate receiving area for Hinkley discharges)*
- **Intertidal and subtidal areas of the Parrett & Avon estuarine** *(mud flats and salt marsh)*
- **Intertidal areas of the Severn estuary and Gwent levels coast**
- **Intertidal and sub-tidal areas of major south Wales estuaries** *(Wye, Usk, Lloughor etc)*
- **Offshore sites such as Newport Deep and Nash Passage**

- **Significant deposits of fine sediment also occur in the estuaries of other south Wales rivers eg: Loughor, Gwendraeth/Towy/Taf)**
- **sheltered coastal embayments (Swansea Bay, Carmarthen Bay**

Bristol Channel Major Parameters



South Wales coastal Critical Groups 1

- **Those people, in a given area, who are likely to receive the highest doses**
- Industry & regulator pathways for doses from sea discharge:
  Dietary (sea food), occupancy, skin contact
- Missed pathways for doses from sea discharge
  Dietary (coastal produce), inhalation (sea spray, aerosols & vapours),
  Inhalation (dusts/suspended particles)

- **Sea to Land Transfer:**

1: **Pasture grass: Dyfed:** Sellafield sea discharged Cs 137 *(200 kms from source)* 10 miles inland:

2: **"Local" foodstuffs from Devon estuary:** higher dose than Hinkley: due Co60 discharges from Devonport nuclear submarine base *(30 kms from source)*

3: **Hebridean islanders:crofting lifestyle**: elevated doses of marine Cs 137, due sea to land transfer: *(200+ kms from source).* Average dose of marine Cs 137 alone **from terrestrial produce** higher than doses of multiple radio isotopes received by some seafood Critical Groups at nuclear sites

South Wales Coastal Critical Groups 2

- **Those people, in the South Wales coastal zone, who are likely to receive the highest doses are:**
- **Populations living where airborne sea to land transfer may occur** *(dietary, inhalation, contact doses)* prevailing winds
- **Populations living where coastal inundations may occur** *(Inhalation dose)*
- **Seafood eaters** *(dietary)*
- **Populations working in maritime activities and sports** *(contact dose)*
- **Populations spending time on the intertidal***: fishers, cocklers (contact dose)*
- **Lack of information**

  No regular monitoring of South Wales marine and terrestrial coastal zone (between Anglesey and Cardiff)

  No modelling of South Wales coastal population radioactivity doses

  No empirical observations of South Wales radiological body burdens